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Was LIA synchronous with equa-tropical climate? A multiproxy study from the southwest coast of India

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ABSTRACT

A comprehensive study of the Mundrothruthu (MT) core (70 cm) from the Asthamudi wetland in Kollam, Kerala, India reveals three climate phases during the Little Ice Age (LIA) through multi-proxy investigations. The period (1507–1518 CE) shows high agricultural activity indicated by abundant diatom diversity, significant terrestrial influx, and freshwater runoff. Elevated TOC% and $\delta^{13}C_{TOC}$ values suggest high temperature and a warm, humid climate, likely driven by high terrestrial influx and transport of organic matter from the nearby surroundings. This may have increased the organic matter influx to the estuary leading to high TOC% and more negative $\delta^{13}C$ values. The second phase (1519–1548 CE) is characterized by increased marine incursion due to enhanced tidal currents, evidenced by a rise in marine palynomorphs, mixed terrestrial and marine organic matter, less negative $\delta^{13}C$ values, and increased mud content. This shift likely reflects changes in sea level or tidal dynamics. The final period (1548–1804 CE) is marked by further enhancement of marine taxa, lower TOC%, and $\delta^{13}C_{TOC}$ values, indicating reduced atmospheric CO_2 and a temperature decrease of about 1 °C. This period is associated with reduced solar insolation and a southward shift of the Inter Tropical Convergence Zone (ITCZ). The study highlights both synchronous and asynchronous climatic behavior on the southwest coast of India relative to global changes during the LIA. Initially warm and humid with high agricultural productivity, the region gradually shifted to marine-dominated conditions due to tidal dynamics and broader climatic shifts. These findings underscore the complex interplay between local and global climatic factors during the LIA.

1. Introduction

The relationship between global temperatures and atmospheric circulation patterns is crucial in understanding Earth's climate dynamics. The Holocene epoch (11,700 years) continues to the present day experiences variations in temperature that indeed influenced atmospheric circulation, albeit to a lesser extent compared to earlier epochs like the Pleistocene (Palacios et al., 2015, 2023). During the Holocene, shifts in temperature have led to changes in atmospheric circulation patterns, affecting phenomena like precipitation distribution. This has profound implications for various aspects of Earth's environment, including glacier evolution. By studying these changes, scientists gain insights into the spatial distribution of precipitation during the Holocene, which is pivotal in understanding how glaciers have waxed and waned over time. During the past two millennia, the earth experienced numerous episodes of extreme warming and cooling due to natural and anthropogenic climate variations contributing to the fact that these climate events were uneven, affecting the world at different times and multitude scales. Amongst these well-known warm periods, the "Medieval Climate Anomaly (MCA)" associated with elevated temperatures existed around 800–1200 AD while the cool period comprise the "Little Ice Age (LIA)" characterized by colder-than-average temperatures and glacier advances between the 14th to mid-19th centuries (Morellón et al., 2011; Nieto-Moreno et al., 2013; Esper et al., 2012; Luterbacher et al., 2016; PAGES 2k Consortium, 2019; Wanner et al., 2022; Gauld et al., 2023). The importance of LIA was recognized as a significant period of glacial

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